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Diagrid Systems for Response Spectrum Analysis with Regular and Irregular Structures using ETABS

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ABSTRACT

One of nature's most catastrophic calamities, earthquakes cause destruction to structures and fatalities. Due to the requirement for architecture view in buildings, the abnormalities of a building or an asymmetrical system are frequently discovered during construction. Today, the utilisation of structures and financial constraints necessitate the construction of tall and unconventional structures in metropolitan areas. Therefore, it is crucial to suggest policies to lessen the harm that an earthquake will cause to these structures. Given the elevated danger of injury compared to ordinary structures, strict guidelines for the design and study of unique structures have been implemented. Varied structural flaws come in different shapes and sizes, but they are primarily grouped into two categories: horizontal irregularities and vertical abnormalities. Both abnormalities are taken into account in the study. With changes in the strength of the frame in the irregular construction, the current work aims to investigate the proportional distribution of lateral forces resulting from earthquake action at each floor level. The uncommon G + 14 vertical building is modelled as a simplified lump mass model in line with the requirements of the Bureau of Indian Standard (BIS) 1893: 2002 (part1) in order to assess the rigidity of the floors. To analyse variables such as story base shear, story displacement, and storey drift under seismic force is. This analysis demonstrates that it is based on supporting the shear foundation and the building's level of performance under the harsh zone in India. The outcome confirms that a weakly constructed building will give stability and draw the storey shear, according to the conclusion. For modelling and analysis, CSI-ETABS commercial software and soft computer software are employed.

***KEYWORDS:** Drift, Displacement, ETABS, Dynamic Irregularity, Lump mass*

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I. INTRODUCTION

This could be a devastating earthquake in the future. Where possible, it is necessary to evaluate the effectiveness of disaster management structures in both these new and existing structures.

Earthquakes are the most unexpected and destructive of all natural disasters, the most difficult to maintain on engineering and life buildings, against them. Therefore, in order to overcome these problems we need to identify the seismic activity of the area created by the development of various analytical processes, which ensures that buildings are able to withstand minor earthquakes and produce adequate monitoring whenever major earthquake events occur. So that can save as many lives as possible. There are several guidelines around the world that have been frequently reviewed on this topic. An analysis process that measures seismic force and your need depending on the value and cost, the method of structural analysis varies from line to line. The behavior of a building during an earthquake depends on several factors, durability, sufficient lateral strength, ductility, flexibility and normal configuration. Buildings with normal geometry and evenly distributed size and durability in plan and height have very little damage compared to conventional suspensions. But nowadays the need and the need for the next generation and the growing number of people have made architects or engineers inevitable in planning unusual designs. Earthquake engineering has therefore developed important issues in understanding the role of architectural planning.

Type of Plan Irregularity

Torsional Irregularity- A building is torsionally irregular, where the maximum horizontal displacement of any floor to the direction of lateral force on the other side of the floor is more than 1.5 times the horizontal displacement at the far end of the floor area.

Re-entrant Corners- The configuration of a building plan and its system of resistance on the sides consists of re-entrant angles, where both the projections of the building beyond the re-entrant angle is more than 15% of the size of its plan on the given side.

Diaphragm Discontinuity- Diaphragms with sudden breakdown or stiffness divergence, including those with more than 50% cut or open area of the closed diaphragm or solid diaphragm stiffness changes of more than 50percent from one floor to another.

Out of plane offsets- When the walls of a building or frames are removed from the plane on any floor and the height of the building

Non-parallel systems- - where vertical building systems withstand indirect lateral forces on two main orthogonal axis in the system.

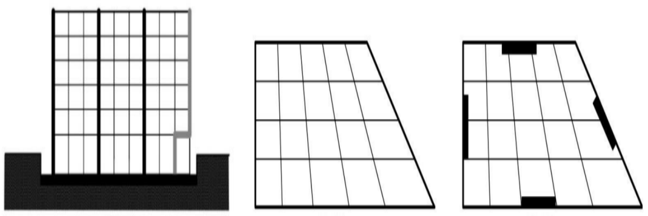


Fig 1.1: Out-of-plane of sets in Vertical Element (i) Moment Frame building (ii) Moment Frame Building with Structural wall

Figure 1.2 Conventional structure and Diagrid structure.

To understand the Seismic performance of G+14 building with a different irregularities in a moderate earthquake zone (III) of India due to combining effect of Vertical geometrical irregularity, Mass irregularity, and Diaphragm irregularity, and also find out the most vulnerable building among them.

- To study the structural performance of multi-storey regular and irregular RC buildings located in zone III under seismic loads.
- To carry out response spectrum analysis of regular, vertical irregular and horizontal irregular (G+14) RC buildings as per IS 1893:2016 (part-I) criteria using CSI ETABS Software.
- To evaluate various seismic responses like Base shear, Storey displacement, Storey drift, and Storey shear of the different irregular buildings and their comparison.

ETABS models of Regular model of rectangular shape, model with horizontal irregularity and vertical irregularity without diagrid is compared with same geometrical models with diagrid. Here, the diagrid section are made of steel material. Dynamic Linear analysis of 6 models are performed and analysed to obtain seismic results and compared.

II. LITRATURE REVIEW:

Nawal and kakade (2017), analyzed a diagrid structural system using ETABS. This work looks at a 32-story unequal building 95m from the ground floor, where the height of each floor is 3m. The analysis method used to analyze is the response spectrum using a combination of modal complete quadratic combination (CQC) guides. In this work, the structure is inserted as a pole and separated by modules as a diagrid pattern. These modules are distributed evenly across the total number of issues. Diagrids are considered pin-ended so that they can withstand the cut and the moment only in axial action. Therefore, the design will be limited to determining the size of the area and the categories of members.

Maria and Elena(2017) "Secondary bracing systems for diagrid structures in tall buildings". In this paper the authors describe the framework for assessing the issues of " area " in the construction of tall diagrid buildings, and then present a method for determining the need for a particular secondary bracing system (SBS) as a diagrid geometry function. . In addition, the design methods of the second integration systems are applied and applied to 90 story building models, characterized by diagrid structures corresponding to different module lengths and cross-sectional diagonal sections. The results of the proposed simplified procedures, both to assess the need for SBS and the subsequent SBS member design, have been compared with the diagram of the diagram structure model, obtained externally and SBS, showing both the accuracy of the proposed structure and the proposed structure. the main importance of the area questions interviewed. In fact, all diagrid models analyzed showed problems related to the stability of the inner columns (i.e., multi-storey binding modes) and / or spatial flexibility (excessive interstory flooding); the above local problems are completely solved after the introduction of the SBS in the central central area, and, against a moderate increase in structural weight (approximately 3%), any dynamic involvement of the diagrid member is eliminated.

Irfan and Tengli (2018), Parametric Study on Asymmetric Diagrid Structures. The contribution of the side-by-side load system, case number, type and degree of asymmetry should be carefully identified and calculated in order to better design and avoid potential damage to buildings. The purpose of this work is to explore different behavior parameters of unequal structures by analyzing and modeling different floor structures using three consecutive analysis methods (Spectrum Response Method) using ETABS Software. In this study the Circular Diagrid structure with the shape of Asymmetric With and Without core Shear Walls is modeled and analyzed. All models / buildings are analyzed and compared with results such as major floor flooding, floor migration, Storey Shear and conclusions are presented at the end of the paper.

Kumar and Kumar(2019), Response of Multi-Storeyed Buildings Having Vertical Irregularities using ETABS. The purpose of this study was to analyze common and irregular vertical structures in order to understand the response of abnormal structures using advanced software such as ETABS. Analysis is performed to understand the behavior of structures by performing Non-Linear Dynamic (Nonlinear Time-History Analysis) analysis software. Structural responses are analyzed to identify three different defects, namely: i) bulk inconsistencies ii) inconsistencies with durability iii) inconsistencies. The reaction of the unusually erected buildings with a typical structure is made taking into account the Base shear, Displacement and Story Drift of buildings. Non-structural structures in the system will easily cope with the effects of torsion because their center of gravity does not correspond to the area of gravity, as torsion will be developed in the structure. When it comes to buildings that are uneven in height and earthquake zones, understanding the behavior of those unusual vertical structures will be difficult.

Kumar et al, (2020), Seismic Analysis of Vertical Geometric Irregular Diagrid Structures with Different Diagonal Angles. This paper presents a brief study of diagrids in an unusual vertical structure. In this study a building with a height of 36 m × 36 m and 168 m height was considered. The height of each floor is 3.5 m. Diagrid with two equal angles of all lengths is provided as a counter-load resistance system. Analysis of the reaction spectrum was performed using ETABS 2018. The seismic performance of an unusual geometric vertical structure provided by diagrids is assessed using diagrid angles. The results in terms of major floor displacement, major floor erosion, time and foundation shear are compared. The current study consists of modeling and analysis of the structure of a metal diagrid with a different angle of diagrid with direct equilibrium in terms of models with different dimensions of the lengths of the sides (A> 0.125L) below the earthquake.

Rahman and Shimpale (2021),Analysis of Effect of Structural Irregularity in Multistorey Building under Seismic Loading. Existing work describes different types of reinforced concrete (RC) that have different irregularities but have the same size that are analyzed to study their behavior when placed between seismic lateral loads. All frames are analyzed by the same strategy as stated in Is 1893-Part-1: 2002. Finally, it has been interpreted that the basic (normal) frame changes less damage while the wrong structure shows greater damage. Testing proves that faulty is not safe in buildings and it is important that you have normal and simple independent conditions in addition to distributing the same load within the building. Complex structures that look like ordinary days, but are in danger of being damaged during an earthquake. Therefore, such structures should be effectively designed with the proper care of their dynamic behavior.

III. EXPERIMENTAL PROGRAM:

The following are the models considered for the analysis, where 3 models are with diagrid and other 3 models without diagrid. Models include vertically irregular and horizontally irregular models.

Model 1: Regular building without diagrid and irregularity

Model 2: Building with horizontal irregularity

Model 3: Building with vertical irregularity

Model 4: Regular building with diagrid

Model 4: Building with horizontal irregularity and diagrid

Model 5: Building with vertical irregularity and diagrid.

The basic required data for a building to be modeled in software includes geometrical properties of each and every story of the building, material properties of the required material to be used in the structure to obtain the required strength, and section properties of the structural elements

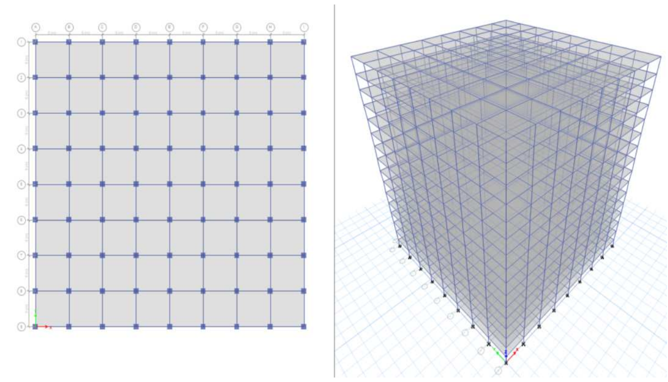


Fig 3.1: Plan view and 3D view of Regular building.

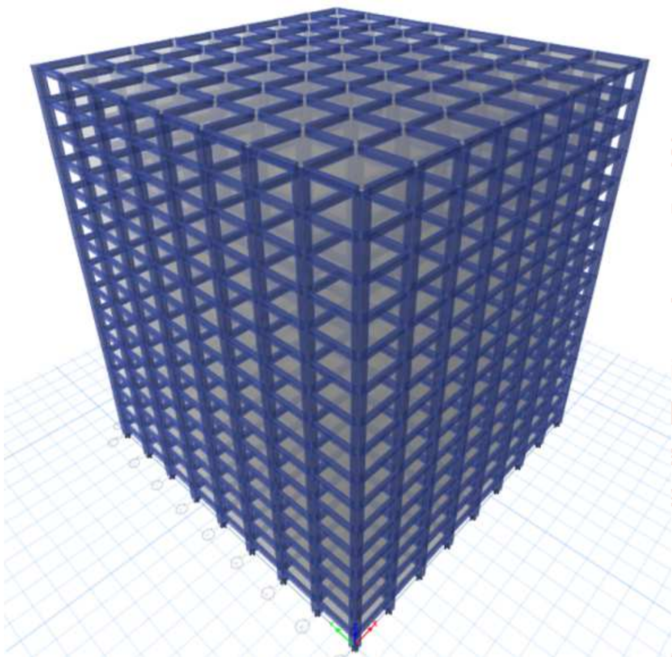


Fig 3.2: Extruded view of Regular building model

IV. METHODOLOGY:

The construction of the RC framework can be large if it is designed to behave without causing damage, and as a result the project may not be economically viable. Conversely, a building must be demolished to make way for an earthquake. Thus, according to the philosophy of earthquakes, (a) under major earthquakes from time to time, structural damage is acceptable. Therefore, buildings are philosophically designed, (a) under extreme earthquakes, structural damage is acceptable, but collapses are unacceptable, and (b) under occasional earthquakes, structural damage is limited even if non-structural damage is unacceptable. Therefore, structures are designed with only a small fraction of the force if they are designed to remain flexible during the expected strong earthquakes and thus allow damage under minor earthquakes. Therefore, seismic design scales reduce costs and acceptable damage, thereby making the project more efficient.

A dynamic analysis is required to obtain the design seismic force and its distribution at different levels along the height of the building and at different lateral load-bearing elements for the following buildings:

a) Regular Buildings -Those that are more than 40 m in height in Zones IV and V and those that are more than 90 m in height in Zones II and 111.

b) Irregular Buildings – All frame buildings over 12m in height in Zones IV and V and those over 40m in height in Zones 11 and III.

This method describes a series of forces acting on a building to represent the effect of an earthquake, usually defined by a seismic response spectrum. It thinks the structure responds in its own basic way. For this to be true, the structure must be low and unstable as the earth moves. The functionality of this method is extended to many building codes using features that affect high-rise buildings with a specific high mode, as well as low twisting levels. To account for the results due to the "permission" structure, many codes use conversion features that reduce design capabilities (eg power reduction features). An equitable vertical analysis method is a straight vertical process, in which the structural response is considered as a linear expansion method. Analysis performed by IS1893-2002.

GRAVITY LOADS

- ➢ Dead load
- ➢ Live load

Dead load

- ➢ Self-weight of beams, columns
- ➢ Slab load (125 mm thick)
- ➢ Wall load

Live load

The live load of the structure is taken for typical floors is $3kN/m^2$ (as per IS: 875 part-2), for terrace $1.5\text{-}2kN/m^2$

LATERAL LOADS

- ➢ Seismic load
- ➢ Wind load

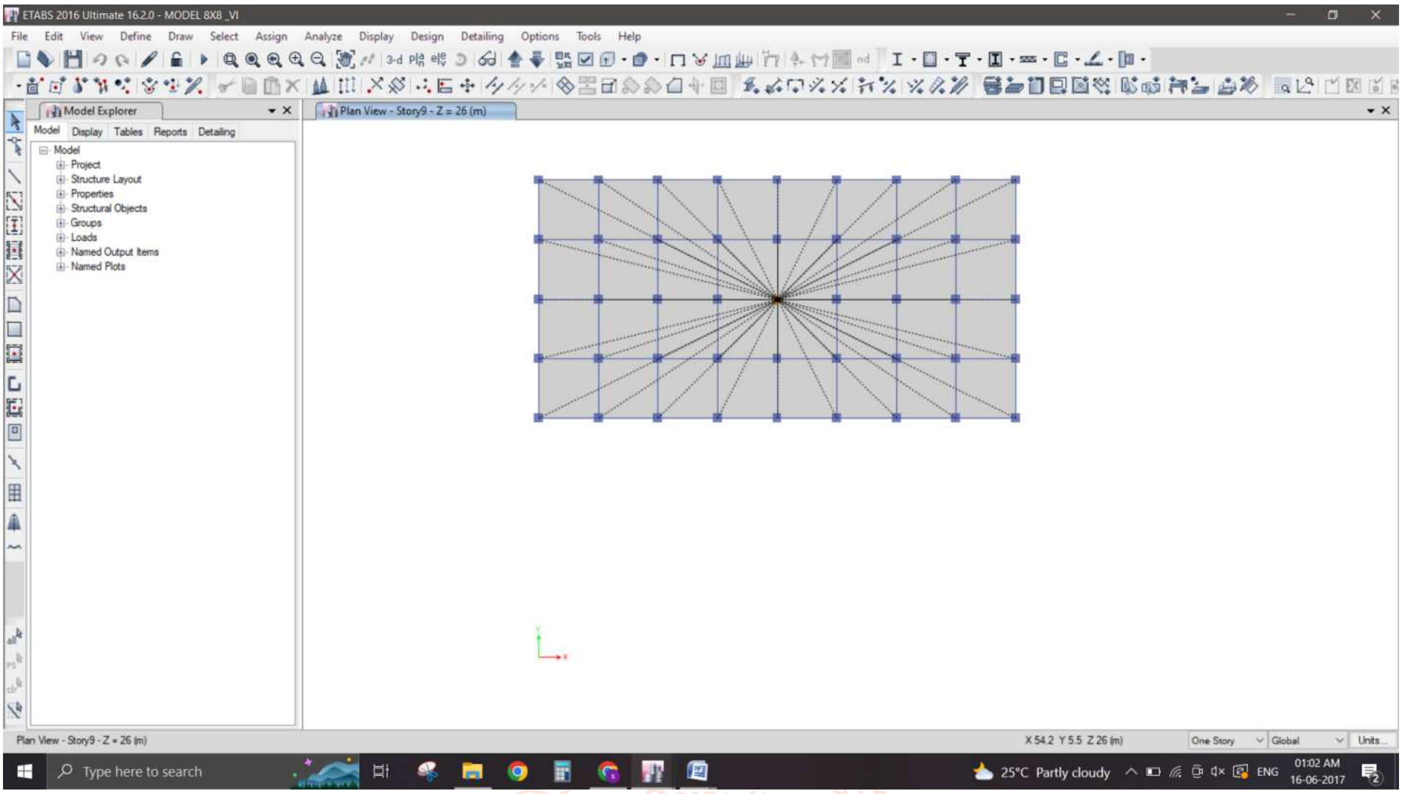
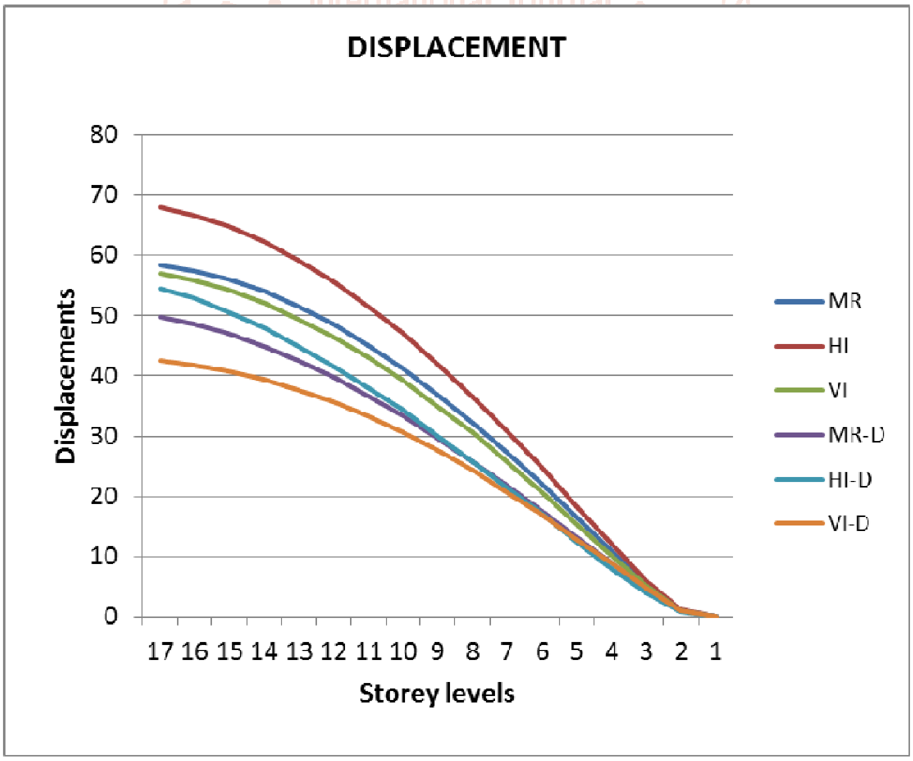


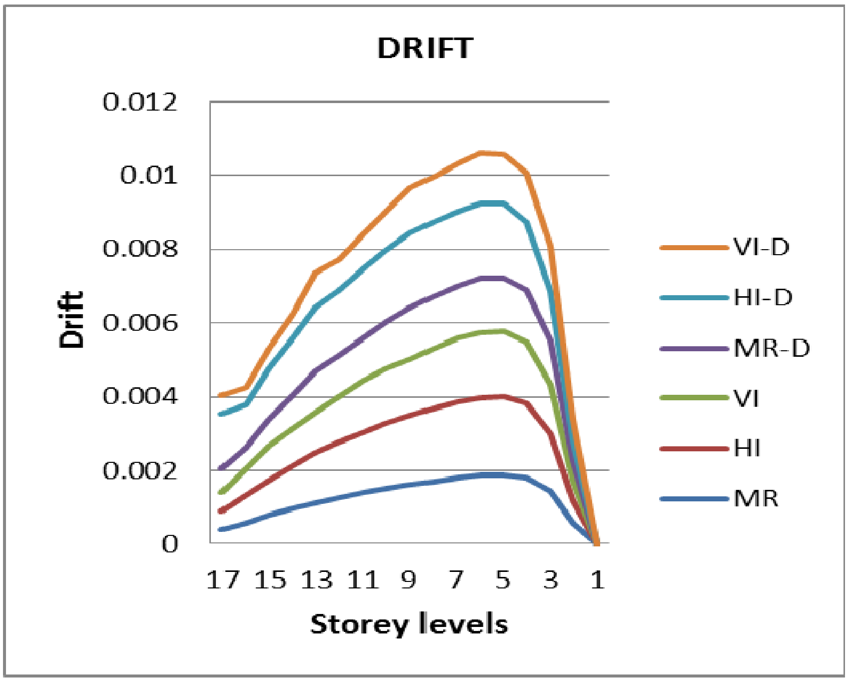
Fig 4.1: Diaphragm of vertical irregular building model till storey 12

V. RESULT AND DISCUSSION

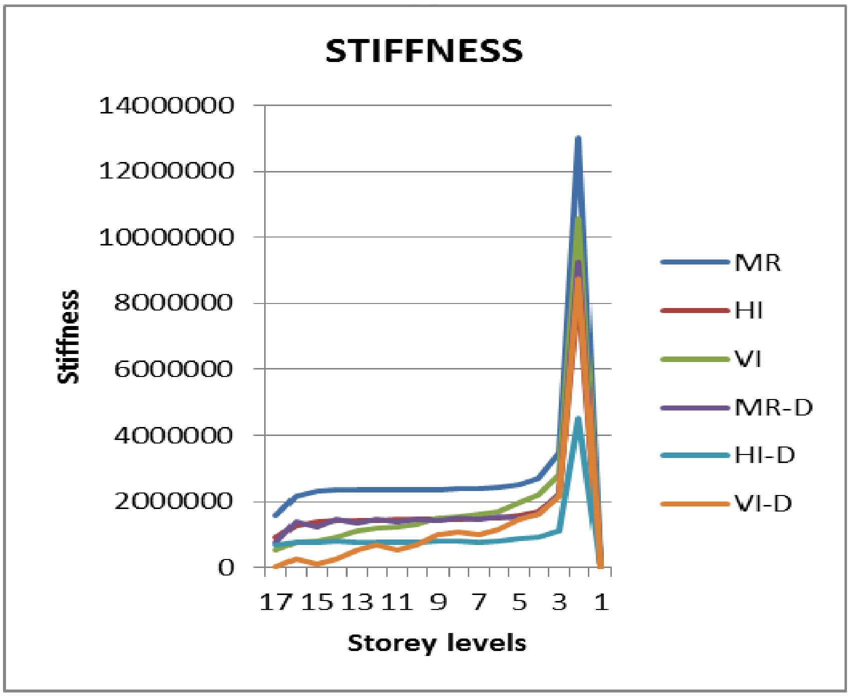
Response spectrum analysis gives realistic behaviour in analyzing a structure under seismic load applications. The following are the results obtained from the ETABS after analyzing the models.



Graph 5.1: Storey levels vs Displacements



Graph 5.2: Storey levels vs Drifts



Graph 5.3: Storey levels vs Stiffness

Maximum stiffness is observed in regular model with rectangular shape with value 13005743.2 kN and least value for model with horizontal irregularity with diagrid with value of 4520476.14 Kn.

VI. CONCLUSION:

In the present study, seismic parameters such as storey displacement, storey drifts, lateral load to stories and static pushover curves for base force v/s monitored displacement plots are obtained.

- The target displacement limit has shown no failure when the structure is subjected to analysis.
- In this study more displacements are formed in horizontal irregular model and least in model of vertical irregular with diagrid.
- Also it has seen that the maximum stiffness are formed in regular building model. The structure models analyzed in this state is safe.
- Maximum storey drift results are also high in horizontal irregular model without diagrid.
- The maximum drifts is within the value of target drift that is assumed. The behavior of the structure is significant to resist the lateral loads.

VII. SCOPE FOR FURTHER STUDY

- To perform various angles of diagrid for regular structures and irregular structures to find out optimum angle and section.
- To perform different models with various irregular i.e., horizontal or vertical models of high rise buildings and analyse with diagrid at effective locations

To analyse asymmetric building with irregular geometry of plan and or combination of horizontal and vertical irregularity.

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